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Cooling Load Estimation and Air Conditioning Unit Selection for Hibir Boat

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ABSTRACT

The variables affecting cooling load calculations are numerous, often difficult to define precisely, and always intricately interrelated. Many cooling load components vary in magnitude over a wide range during a twenty four hour period. Since these cyclic changes in load components are often not in phase with each other, each must be analyzed to establish the resultant maximum cooling load for a building or zone.
Not only does this over sizing impact the heating and cooling equipment costs, but duct sizes and numbers of runs must also be increased to account for the significantly increased system airflow.

In this cooling load estimation it is undertaken different variables to propose optimum air conditioning system needed to deliver conditioned air to the rooms to meet the occupant's comfort expectations at the indoor conditions.
For the larger room a total capacity of 172140 BTU/hour should be provided to meet the requirement. In addition 100253 BTU/h is also required for the two passenger rooms.

Due to the limitation of space for the duct system it is proposed that split type air conditioning is proposed because there is no sufficient space to pass the duct through the roof or through the wall.

KEY WORDS: *Hibir Boat, Cooling Load Estimation, Internal Cooling Load, External Cooling Load*

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I. INTRODUCTION

When designing a heating, ventilating, and air-conditioning (HVAC) system, perhaps the first thought that comes to mind is to select a system that is large enough to keep the indoors at the desired conditions at all times even under the worst weather conditions. But sizing an HVAC system on the basis of the most extreme weather on record is not practical since such an oversized system will have a higher initial cost, will occupy more space, and will probably have a higher operating cost because the equipment in this case will run at partial load most of time and thus at a lower efficiency.

Air conditioner sizing is based on heat gain, and/or losses in a building. It is obvious that is need to remove the amount of heat gain if the outside temperature greater. Similarly, it may require adding in the heat loss from the space - if outside temperature is cold. In short, heat gain and loss, must be equally balanced by heat removal, and addition, to get the desired room comfort that we want.

In this design it is desired to make the inside space of the boat comfortable to the occupants. To meet the desired objective we need to reject heat from the boat to the surrounding environment. Hence the total heat gain from the internal and external will be determined with grate accuracy not to under size or over size of the air conditioning system.

One of the constraints that exist in this boat design air conditioning system is space for the duct and the electric power supply to run the units.

The components of the boat cooling load are; direct solar radiation, transmission load, ventilation/ infiltration load and internal load. Calculating all these loads individually and adding them up gives the estimate of total cooling load. The load, thus calculated, constitutes total sensible load. Normal practice is that, depending on the building type, certain percent of it is added to take care of latent load. Applying the laws of heat transfer and solar radiation makes load estimations [1].

Matching its size to meet the comfort of the occupants would need to consider the internal environments, equipments, occupants and also the building make up materials in addition the external environments the air conditioning efficiency, performance, durability, and cost depend on.

1.1 Design Parameters

The critical inputs and their associated risks discussed in this guide are:

i. Design Conditions
- Location
- Latitude
- Elevation
- Outdoor temperature and relative humidity

ii. Orientation

iii. Internal conditions
- Indoor temperature and relative humidity

iv. Building Enclosure
- Insulation levels of walls, ceilings and floors
- Window specification
- Thermal conductivity
- Solar heat gain coefficient (SHGC)
- Infiltration and ventilation levels
- Interior and exterior shading

v. Internal loads
- Number of occupants
- Electronics, lighting and appliances [2].

The heating and cooling load calculation is the first step of the iterative HVAC design procedure; a full HVAC design involves more than the just the load estimate calculation. Right-sizing the HVAC system, selecting HVAC equipment and designing the air distribution system to meet the accurate predicted heating and cooling loads, begins with an accurate understanding of the heating and cooling loads on a space.

1.2 Sizing Air-Conditioning System

The heat gain or heat loss through a building depends on:

a. The temperature difference between outside temperature and the desired temperature.
b. The type of construction and the amount of insulation is on ceiling and walls.
c. How much shade is on building's windows, walls, and roof
d. Size of the room and surface area of the walls.
e. The amount of air leaks into indoor space from the outside. Infiltration plays a part in determining our air conditioner sizing.
f. The number occupants.
g. Activities and other equipment within a building. Cooking? Hot bath? Gymnasium? Meeting? etc
h. Amount of lighting in the room.
i. How much heat the appliances generate. Number of power equipments such as oven, washing machine, computers, TV inside the space; all contribute to heat.

The air conditioner's efficiency, performance, durability, and cost depend on matching its size to the above factors. Many designers use a simple square foot method for sizing the air-conditioners. The most common rule of thumb is to use "1 ton for every 500 square feet of floor area". Such a method is useful in preliminary estimation of the equipment size. The main drawback of rules-of-thumb methods is the presumption that the building design will not make any difference. Thus the rules for a badly designed building are typically the same as for a good design.

For estimating cooling loads, one has to consider the unsteady state processes, as the peak cooling load occurs during the day time and the outside conditions also vary significantly throughout the day due to solar radiation. In addition, all internal sources add on to the cooling loads and neglecting them would lead to underestimation of the required cooling capacity and the possibility of not being able to maintain the required indoor conditions. Thus cooling load calculations are inherently more complicated.

The size of a heating or cooling system for a building is determined on the basis of the desired indoor conditions that must be maintained based on the outdoor conditions that exist at that location. The desirable ranges of temperatures, humidities, and ventilation rates.

Over sizing the HVAC system is detrimental to energy use, comfort, indoor air quality, building, and equipment durability. All of these impacts derive from the fact that the system will be "short cycling" in both the heating and cooling modes. To reach peak operational efficiency and effectiveness, a heating and cooling system should run for as long as possible to meet the loads.

1.3 Heat Flow Rates
In air-conditioning design, four related heat flow rates, each of which varies with time, must be differentiated:

a. Space heat gain: - how much heat (energy) is entering the space
b. Space cooling load: - how much energy must be removed from the space to keep temperature and relative humidity constant
c. Space heat extraction: - how much energy is the HVAC removing from the space
d. Cooling load (coil): - how much energy is removed by the cooling coil serving various spaces plus any loads external to the spaces such as duct heat gain, duct leakage, fan heat and outdoor make up air?

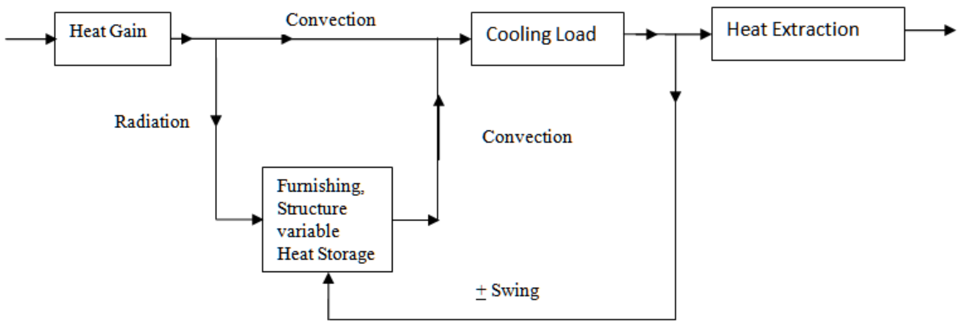

Figure 1 Conversion of heat gain into cooling load [6]

1.4 Space Heat Gain
This instantaneous rate of heat gain is the rate at which heat enters into and/or is generated within a space at a given instant. Heat gain is classified by the manner in which it enters the space:-

a. Solar radiation through transparent surfaces such as windows
b. Heat conduction through exterior walls and roofs
c. Heat conduction through interior partitions, ceilings and floors
d. Heat generated within the space by occupants, lights, appliances, equipment and processes
e. Loads as a result of ventilation and infiltration of outdoor air
f. Other miscellaneous heat gains

1.5 Sensible and Latent Heat Gain
Sensible heat is the heat which a substance absorbs, and while its temperature goes up, the substance does not change state. Sensible heat gain is directly added to the conditioned space by conduction, convection, and/or radiation. Note that the sensible heat gain entering the conditioned space does not equal the sensible cooling load during the same time interval because of the stored heat in the building envelope. Only the convective heat becomes cooling load instantaneously.

1.5.1. Sensible heat load
Sensible heat load is total of

a. Heat transmitted through floors, ceilings and walls
b. Occupant’s body heat
c. Appliance and light heat
d. Solar heat gain through glass
e. Infiltration of outside air
f. Air introduced by ventilation

1.5.2. Latent Heat Loads
Latent heat gain occurs when moisture is added to the space either from internal sources (e.g. vapor emitted by occupants and equipment) or from outdoor air as a result of infiltration or ventilation to maintain proper indoor air quality. Latent heat load is total of

a. Moisture-laden outside air form infiltration and ventilation
b. Occupant respiration and activities

To maintain a constant humidity ratio, water vapor must condense on cooling apparatus at a rate equal to its rate of addition into the space. This process is called dehumidification and is very energy intensive, for instance, removing 1 kg of humidity requires approximately 0.7 kWh of energy.

1.6 Cooling Load Calculation Method

For a thorough calculation of the zones and whole building loads, one of the following three methods should be employed:

i. Transfer Function Method (TFM): This is the most complex of the methods proposed by ASHRAE and requires the use of a computer program or advanced spreadsheet.
ii. Cooling Load Temperature Differential/Cooling Load Factors (CLTD/CLF): This method is derived from the TFM method and uses tabulated data to simplify the calculation process. The method can be fairly easily transferred into simple spreadsheet programs but has some limitations due to the use of tabulated data.
iii. Total Equivalent Temperature Differential/Time-Averaging (TETD/TA): This was the preferred method for hand or simple spread sheet calculation before the introduction of the CLTD/CLF method.

II. DESIGN INFORMATION

To calculate the space cooling load, detailed building information, location, site and weather data, internal design information and operating schedules are required. Information regarding the outdoor design conditions and desired indoor conditions are the starting point for the load calculation.

1. Outdoor design weather conditions
2. Indoor design conditions and thermal comfort
3. Indoor air quality and outdoor air requirements
4. Building characteristics

To calculate space heat gain, the following information on building envelope is required:

   a. Architectural plans, sections and elevations – for estimating building dimensions/area/volume
   b. Building orientation (N, S, E, W, NE, SE, SW, NW, etc), location etc
   c. External/Internal shading, ground reflectance etc.
   d. Materials of construction for external walls, roofs, windows, doors, internal walls, partitions, ceiling, insulating materials and thicknesses, external wall and roof colors.
   e. Amount of glass, type and shading on windows

5. Operating Schedules

Obtain the schedule of occupants, lighting, equipment, appliances, and processes that contribute to the internal loads and determine whether air conditioning equipment will be operated continuously or intermittently (such as, shut down during off periods, night set-back, and weekend shutdown). Gather the following information:

- Lighting requirements, types of lighting fixtures
- Appliances requirements such as computers, printers, fax machines, water coolers, refrigerators, microwave, miscellaneous electrical panels, cables etc
- Heat released by the HVAC equipment.
- Number of occupants, time of building occupancy and type of building occupancy

2.1 Design Data

Hibir Boat will give service between Bahir Dar and Gorgora port and also seal throughout Lake Tana. In this cooling load analysis it is assumed that the boat is at Bahir Dar port and the window having large glass size is facing to the South. The following data is considered for the calculation of the cooling load.

City/Town	Latitude	Longitude	Elevation [4]
Bahir Dar	$11^{0}37'$N	$37\ ^{0}10'$E	1800 m

Maximum DBT 32.39 ^{o}c (90 $^{o}{}_{F}$)
Minimum DBT 8.8 ^{o}c (47.5 $^{o}{}_{F}$)
Monthly Daily Range 23.59 ^{o}c (74.5 $^{o}{}_{F}$)

Table 1 Hibir Boat Basic Dimension

Purpose of the Room	**Width [ft]Floor/Ceiling**	**Length [ft]**	**Ceiling Height [ft]**	**Number of Occupant**	**Computer/Laptop**	**Number of Bulbs**	**Speakers [watt]**
Meeting Hall	23	63	7.5	90	90	20	1500
Passenger rooms (2 in number)	8	40	6.0	50	-	8	-
Door	8.0	6.5	-	-	-	-	-

III. COOLING LOAD CALCULATION

The total cooling load on a building consists of external as well as internal loads. The orientation of Hibir boat must be considered in the cooling load calculation due to changing solar heat gains at various times of the day and the impact of those gains.

The orientation of the boat can greatly affect the sensible heat gain on the house depending on the ratio of windows to opaque walls and the degree of shading from the sun.
Often times, the peak cooling load for the worst case orientation is acceptable for system sizing; however, if there is a significant difference between loads at various orientations, system sizing may vary for the same boat.

Table 2 Basic calculation of wall and door area for the meeting hall

Wall Orientation	**Total wall Area [ft^2]**	**Window Area [ft^2]**	**Door Area [ft^2]**
North	466	186	-
South	466	186	-
West	172	69	-
East	172	-	109
Roof	1187	-	-
Floor	1448	-	-

Note:-

- The window covers 40% of the total wall area of the three faces except the East wall
- Single window type
- No shadow at window

Table 3 Basic calculation of wall area for the passenger rooms

Wall Orientation	**Area [ft^2]**	**Window Area [ft^2]**	**Door Area [ft^2]**
North	248	49.6	20
South	248	49.6	20
West	49	-	-
East	49	-	-
Roof	266	-	-
Floor	314	-	-

Note:-

- the window covers 20% of the total wall area of single wall
- Single window type
- No shadow at window

Table 4 Components and Contribution of heat load

Cooling Load Components	**Sensible Load**	**Latent Load**	**Space Load**	**Coil Load**
Conduction trough roof, walls, window, exterior walls ceiling and sky lights	✓	X	✓	✓
Solar radiation through	✓	X	✓	✓
Conduction through ceiling interior partition walls and floor	✓	X	✓	✓
People	✓	✓	✓	✓
Lights	✓		✓	✓
Equipment appliance	✓	✓	✓	✓
Infiltration	✓	✓	✓	✓
Ventilation	✓	✓	✓	✓
System heat gains	✓	X	X	✓
Fans	✓	X	X	X

3.1 Internal Cooling Loads

The various internal loads consist of sensible and latent heat transfers due to occupants, processes appliances and lighting. The lighting load is only sensible. The conversion of sensible heat gain (from lighting, people, appliances, etc.) to space cooling load is affected by the thermal storage characteristics of that space and is thus subject to appropriate cooling load factors (CLF) to account for the time lag of the cooling load caused by the building mass. The weighting factors equation determines the CLF factors.
CLF = Q cooling load / Q internal gains
Note that the latent heat gains are considered instantaneous.

3.3.1 Heat Gain from Occupants

Q Sensible= N *QS*CLF …………………………………………………………………. 1

Q latent=N *QL ……………………………………………………………………… 2

Where

N = number of people in space

QS, QL= Sensible and Latent heat gain from occupancy

CLF = Cooling Load Factor, by hour of occupancy

Occupants Steady at rest

Q Sensible = 239 BTU/hr

Q Latent = 137BTU/hr [3,5]

a. For the Hall

Q Sensible = Number of people*Sensible heat gain /person*CLF

Q Sensible = 90*239 = 21510 BTU/hr

Q Latent = 90*137 = 12330 BTU/hr

b. For the Passenger Rooms

Q Sensible = 50*239 = 11950 BTU/hr

Q Latent = 50*137 = 6850 BTU/hr

3.3.2 Heat Gain from Lighting

$Q = \text{Watt} * 3.14 * \text{Blast factor} * \text{CLF}$ ……………………………………………………….3

Where

Blast Factor = 1.2 for florescent

= 1.0 for incandescent

Watt - energy consumed by the light [w]

3.41 - Conversion factor from watt to BTU/hr

CLF - 1.0 (for conditioning system shut off at night) [3]

a. For the Hall

Q lights = 20*60*3.41*1.20*1.0 = 4910 BTU/hr

b. For the Passenger Rooms

Q lights = 8*60*3.41*1.20*1.0 = 1965 BTU/hr

2.3.2 Heat Gain from Electrical Equipments

1. Lap tops (50-150 BTU/hr)

a. For the Hall

Q Sensible = 90*150 = 13,500 BTU/hr

b. For the Passenger Rooms

Q Sensible = 50*150 = 7,500 BTU/hr

2. Sound System

Larger room on speaker having power consumption of 680 BTU/hr

Q Sensible = 1*680= 680 BTU/hr

3. LCD TV 250 Watt

a. For the Hall

Q Sensible =1*250*3.41 = 852.5 BTU/hr

b. For the Passenger Rooms

Q Sensible = 2*250*3.41= 1705 BTU/hr

4. Audio system 35Watt

Q Sensible = 2*35*3.41= 238.7 BTU/hr

3.4 External Cooling Load

The external loads consist of heat transfer by conduction through the building walls, roof, floor, doors etc, heat transfer by radiation through fenestration such as windows and sky lights. All these are sensible heat transfers [3].

3.4.1 Heat Gain from Solar Radiation Through Windows

Solar cooling load (SCL) depends on the following factor: - direction of window faces, time of day, month, latitude construction of interior partition walls, and type of floor covering and existence of internal shading device.

Solar cooling load is to estimate the rate at which solar energy radiates directly into space as a sensible heat gain. SCL factor is account for the capacity of the space to absorb and store heat.

Solar load through glass has two components: 1) Conductive and 2) Solar Transmission

The absorbed and then conductive portion of the radiation through the windows is treated like the roof and walls where CLTD values for standard glazing are tabulated in ASHARE fundamentals handbook. For solar transmission, the cooling load is calculated by the cooling load SCL factor and shading coefficient (SC).

a. For the Hall

Q = A*SC*SCL …………………………………………………..………………………. 4

Where:-

Q - Heat gain by solar radiation through glass [BTU/hr]
SC- Shading coefficient of window [dimensionless parameter]
SCL- Solar cooling load factor [BTU/hr*ft^2]

Since the SCL value for 11^{o}37'N is not available in any air conditioning data books it requires developing specified value or approximating using recommended techniques like interpolation, extrapolation by knowing one relevant value beyond the required one

SCL value for 24^0 N latitude = 275BTU/hr*ft^2
SCL value for 36^0 N latitude= 265BTU/hr*ft^2
SCL value for 48^0 N latitude=242 BTU/hr*ft^2 [4]

For the SCL values not given it is possible to interpolate or extrapolate, therefore by using extrapolation it is obtained that:-

SCL= 277 BTU/hr ft^2
SC = 0.61
Q = 441*0.61*277
= 74,515 BTU/hr

b. For the Passenger Rooms

Q = A*SC*SCL
= 266*0.61*277
= 44946.02BTU/hr

3.4.2 Heat Gain from Solar Conduction Through Windows

a. For the Hall

Q Glass Conductive = U * A * CLTD Glass Corrected
U = 0.98 for single glass fixed frame vertical installation
= 0.98*441*13
= 5618 BTU/hr

b. For the Passenger Rooms

= 0.98*99.2*13
= 1264 BTU/hr

3.4.3 Heat Gain form Infiltration

Infiltration or air leaks into or out of a space through doors, windows and small cracks in the building envelop. The uncontrolled introduction of fresh air into a building, it is most subjective of all losses and oftentimes the largest of all heat losses. Sometimes comprises up to 30% of the total heating load and ends up being an "educated guess" [R]

Method of estimation:-

i. Air change method
ii. Crack method
iii. Effective leakage area method

Among these method of infiltration air change method is used to approximate the cooling load because it is easy for manual calculation without HVAC computers [R].

a. For the Hall

Q sensible = 1.085 * air flow*ΔT
Q Latent = 0.7 * air flow * ΔW
ΔT = To- Ti where To/Ti is Outside/Inside dry bulb temperature, °F
Infiltration air flow = (Volume of space *Air change ratio)/60
Where:-

Infiltration air flow = quantity of air infiltrating in to space [cfm]
Volume of space = Length * width * ceiling height [ft^3]
Air change rate = air change per hours
60 = conversion factor from hour to minute
Volume of space = 63*23*7.5 = 10 868 ft^3
Designer will use 0.3 to 2.0 room air changes per hour

Infiltration air flow = 0.3*10 868/60 = 55 cfm = 0.3*10 868/3600 =0.9cfs
Density of air = 0.075lb/ft^3
Specific heat = 0.24BTU/lb^{o}F
Latent heat of water vapor = 1076 BTU/lb

Q sensible = 1.085 * 55*[90-70]
=1194 BTU/hr

Q Latent=0.7*20*[110-75]
=490 BTU/hr

b. For the Passenger Rooms

Q sensible = 1.085 * air flow*ΔT
Q Latent = 0.7 * air flow * ΔW
ΔT = To - Ti where To/Ti is Outside/Inside dry bulb temperature, °F
Infiltration air flow = 1967/60=10cfm
Q Sensible = 1.085*20* [90-70] = 434 BTU/hr
Q Latent=0.7*20*[110-75] =490 BTU/hr

3.4.4 Conduction Through Walls

Building components construction, proper details, and materials are critical components of the heating and cooling load calculations. The R-value of the building wall, roof, and foundation construction components can be accurately calculated using the insulation levels specified combined with the remainder of the components that make up the construction assembly.

a. For the Large Hall Wall Area

Sixty percentage of the total area of the wall is made of carbon steel and wood composite for all the sides of the wall except the eastern side.
40% = 441 ft^2
60 % = ?
= 662ft^2
A total = A east wall + 662
= 3.3 [2.25+7] + 662 = 833ft^2 =77 m^2

R Total = $\frac{1}{77 m^2}\left(\frac{1}{50w/m^2 k}+\frac{25*10^{-3}}{0.17w/m^2 k}+\frac{6*10^{-3}}{54w/m^2 k}+\frac{1}{50w/m^2 k}\right)$ ………………………… 5
= 2.446*10^{-3} k/w

$Q = \frac{\Delta T}{R} = \frac{[32.39-21]}{2.446*10^{-3}\ k/w}$ = 4657 watt =15879 BTU/hr ……………………………………………….6

b. For the Passenger Wall Area

20% = 99 ft^2
80 % = ?
= 397ft^2
A total = A east wall + 397
= [1.90*2.4*3.3] + 397
= 6.27*7.9+379 = 429ft^2 =39 m^2

R Total = $\frac{1}{39m^2}\left(\frac{1}{50w/m^2 k}+\frac{25*10^{-3}}{0.17w/m^2 k}+\frac{6*10^{-3}}{54w/m^2 k}+\frac{1}{50w/m^2 k}\right)$
= 4.8*10^{-3} k/w

$Q = \frac{\Delta T}{R} = \frac{[32.39-21]}{4.8*10^{-3}\ k/w}$ = 2373Watt = 8092 BTU/hr

3.4.5 Roof

The basic conduction equation for heat gain is q = U A ΔT
Q = U * A * (CLTD) ……………………………………………………………………….
Where:-
Q = cooling load, Btu/hr
U = Coefficient of heat transfer roof, Btu/hr.ft².°F
A = area of roof, ft^2
CLTD = cooling load temperature difference °F.
U = 18.22 Btu/hr.ft².°F
CLTD at max T^o 13^{o}F

Roof area = (19*3.3+7*3.3) = 85.8 ft^2
Q roof= 5.34328*3.41*85.8*13
= 20,323.24 BTU/hr

IV. RESULT AND DISCUSSION:

Table 5:- Summary of space cooling load for meeting hall

Space Load Component	Sensible Heat Load [BTU/hr]	Latent Heat Load [BTU/hr]
Conduction through roof	20323	-
Conduction through windows	5618	-
Conduction through exterior walls	15879	-
Solar radiation through Windows	74515	-
Occupants	21510	12330
Lights	4910	-
Electrical Equipments (Laptop and sound system)	15271	-
Infiltration	1194	490
Total	**159220**	**12920**

Table 6: - Summary of space cooling load for passenger rooms

Space Load Component	Sensible Heat Load [BTU/hr]	Latent Heat Load [BTU/hr]
Conduction through roof	44946	-
Conduction through windows	1264	-
Conduction through exterior walls	8092	-
Solar radiation through Windows	16762	-
Occupants	11950	6850
Lights	1965	-
Electrical Equipments (Laptop)	7500	-
Infiltration	434	490
Total	**92913**	**7340**

The values of the sensible heat load and latent heat load for the meeting hall and the two passenger rooms of Hibir bat which contributes for the change in temperature of the indoor will be summed up to choose the appropriate size of the Air conditioning.

The meeting hall required air conditioning unit having the capacity of 172140 BTU/hour it might be appropriate to make all the capacity for the AC unit of 24,000 BTU/hour which is currently available in Ethiopian market hence e we need to provide 7 units of it to meet the total cooling load.

This unit should be located based on the architectural, size and for the comfort of the occupants it is proposed to keep them 2 the South wall, 2 to the North, 2, west and 1 to the east wall.

The passenger rooms are two in number to the right and left of the meeting hall with each demand 50,127 BTU/hr, hence with the available AC unit of 24,000 BTU/hr it is proposed to use two in the \East and west wall.

The constraints that we do have is the space for the duct hence to have uniform indoor condition it is needed to fix the AC unit in different position to give the same load share in the room as well as the unit should not directly (close) to the body of the occupant not to discomfort them during operation considering all this it is recommended that to fix them close to the ceiling of the boat and in all the four sides of the wall and to align on to the other.

V. CONCLUSION:

Right-sizing the HVAC system begins with an accurate understanding of the heating and cooling loads on a space. The values determined by the heating and cooling load calculation process dictate the equipment selection and the

To get the information which required for equipment selection, system sizing and system design the detail cooling load estimation has been made in as series of steps in the previous section.

The load estimation considers all factors which will affect the indoor condition. Internal heat gain from occupants, equipments and the external heat gain from radiation, conduction and convection are considered during the analysis.

Based on the results of the sensible heat load and the latent heat load for the rooms the capacity of the AC unit is determined to meet the desired indoor condition.

In the selection of the AC unit it is anticipated to be the one which is a available in the country market and the sp[ace constraints that exist in the boat to pass the duct system. Due to the availability of space for the duct system it is not possible to use a central type AC unit and to distribute through the duct hence split type is recommended.

It is proposed to be spilt independent units of 24,000 BYU/hr size AC unit and a total of 11 for all the rooms, the position to fix them considered the comfort of the occupants, the architectural views and the space availability of the rooms.

REFERENCES

[1]. F.A. Ansari , A.S. Mokhtar, K.A. Abbas and N.M. Adam, *A Simple Approach for Building Cooling Load Estimation*, Faculty of Engineering, UPM, Serdang, Selangor Darul Ehsan, Malaysia, American Journal of Environmental Sciences 1 (3): 209-212, 2005

[2]. Arlan Burdick, US Department of Energy, *Energy Efficiency and Renewable energy, Strategy Guideline: Accurate Heating and Cooling Load Calculations,* IBACOS, Inc. June 2011

[3]. A. Bhatia, *HVAC Cooling Load Calculations and Principles*

[4]. Kirk Lindsey, R*evision of CLTD/CLF Cooling Calculation Method,* Oklahoma State University, Stillwater, Oklahoma , 1991

[5]. ASHRAE Fundamentals Handbook (SI), *Nonresidential Cooling And Heating Load Calculations*, 1997

[6]. Joseph F. Cuba, *Cooling and Heating Load calculation Manual*, American Society of Heating , Refrigeration and Air conditioning Engineers, Inc.